

UNIBODY LATHE SPINDLE LINER

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UNIBODY LATHE SPINDLE LINER

5 Technical Field

This invention relates to liners for securely holding a workpiece centered in a machine tool and, more particularly, to a unibody liner for securing a workpiece in the hollow spindle of a turning machine for effectively controlling bar whip and its related problems.

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Background Art

Virtually all metal turning machine tools involve the feeding of bar or tube stock, which is commonly longer than the finished part upon completion of the machining process. Typically, the stock or workpiece is fed through a tubular spindle in the head stock of the machine to a chuck mechanism where the cutting operation occurs. The workpiece is secured by a chuck mechanism during the machining process while the entire length of the workpiece rotates. This rotation is typically at a high rate of revolutions per minute. As a workpiece is finished, a new workpiece is continually fed by an automatic or manual bar pusher rod mechanism.

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When stock smaller than the inside diameter of the spindle is fed through the spindle and is clamped by the chuck mechanism while the entire bar is spinning, the stock remaining inside the spindle will rotate out of concentric rotation (e.g., wobble). This condition, commonly referred to as "whip," results in undesirable machine noise, unacceptable machined part tolerances, poor machine finishes, and vibration or "chatter," which reduces the operator's ability to predict or control the machining operation. Such conditions adversely effect the cutting or quality of the operation, often resulting in stock loss.

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To address this condition and to improve machine performance, particularly at higher revolution speeds, "liners" were developed to fit in the through-opening of the spindle of the turning machine. Such a liner has a tubular shape with an axial opening extending along its entirety. The workpiece then fits through the axial opening of the liner. The liner has an outer diameter equal to part of the inner diameter of the spindle and an inner diameter slightly greater than that of the outside diameter of the bar stock, in order to

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5 concentrically fill the annular space between the workpiece and the inner wall of the spindle. Typically, a cylindrical filler tube or spindle liner for each size of the bar stock was used.

One conventional approach for reducing stock whip in the spindle of a turning machine is a cylindrical reduction tube constructed from metal to form the inside diameter, with a series of annular bearing rings or O-rings to establish the outside diameter. The inside diameter of the reduction tube is typically slightly greater than the outside diameter of the stock for the purpose of concentrically filing or reducing the space between the stock and the spindle, that is, the outside diameter of the reduction tube or liner is roughly equal to the inside diameter of the spindle.

In the use of the aforementioned prior art liner, a particular liner is selected from a set of spindle liners depending on the workpiece to be machined. The liner is inserted into the lathe and secured by way of a mounting flange disposed adjacent to one end of the liner and a set of fasteners (i.e., bolts) securing the liner to the turning machine. When a different sized workpiece is to be machined, the liner must be unfastened and removed to allow the next liner to be positioned and secured within the spindle.

Other prior art liners include those developed by Austin, U.S. Patent No. 4, 058,036; Winberg et al., U.S. Patent No. 4,149,437; Spooner, U.S. Patents Nos. 4, 788,895 and 4,930,381; and Berns et al., U.S. Patent No. 5,649,460. All of the aforementioned prior art devices suffer from being complex in design and expensive to manufacture.

This conventional method of filling the void between stock and the spindle still experiences various problems. First, the metal material of the spindle inner may not allow for feeding of non-uniform or slightly bowed bar stock. Second, when running hex, square, or extruded shaped bar stock, the inner bore of the conventional spindle liner does not take the shape of this stock through its entire length. Utilizing machined pins or dowel rings, the bar stock is only held at few locations (typically 2 or 3) and, therefore, control of the bar as it is fed through the machine is not fully optimized. Third, the metal-to-metal contact between the work piece and the interior of the metal liner has a tendency to mar or scratch the workpiece. Fourth, the metal-to-metal contact in a

5 conventional spindle liner does not fully minimize vibration and the subsequent noise and control problems. This problem can lead to the requirement of several metal spindle liners for multiple bar stock sizes in close size proximity, which becomes expensive. It also can lead to the operator's inability to fully control and optimize the productivity of the machine's cutting operation.

10 In addition, in some cases the weight of the conventional metal spindle liner adds a significant amount of weight to the spindle, increasing the amount of turning mass, which in turn results in additional wear on the machine and the spindle. A conventional metal liner is also corrosive and, over time, will leave amounts of dirt and grime within the interior of the spindle. This adds to cost of
15 maintaining and operating the metal turning machine.

Other concerns include the conventional spindle liner being easily damaged when not in use if dropped or impacted with any moderate degree of force. Finally, the conventional spindle liner requires complex machining and manufacture, which adds to the expense and lead time of conventional liners.

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Disclosure of Invention

The present invention, provides a method and article involving a one-piece, unibody spindle liner formed from urethane material and having a tubular shape with an outside diameter and inside diameter that may be sized to fit
25 virtually any spindle and to readily allow for the feeding therethrough of any size or shape of bar or tube stock.

This invention particularly relates to hollow liners utilized in a wide number of today's machining operations for handling and feeding tubular or bar stock such that the axial centerline of the workpiece is maintained in concentric
30 axial alignment with the working centerline of the turning machine. The liner of this invention may be configured as needed to accommodate workpieces of different sizes and shapes. Heretofore, it was commonly considered prohibitively expensive to provide multiple spindle liners for a large number of bar stock sizes and shapes. This invention eliminates that obstacle by providing
35 a method of forming a one-piece liner that is considerably less expense than conventional liners, thereby enabling an operator of a turning machine to indeed

5 have multiple liners on hand to accommodate the many varying sizes and shapes of bar or tube stock.

10 Through a molding process, the outside diameter of the unibody liner is sized to fit the dimensions of virtually any size spindle. The liner's inner bore and diameter is molded to match and allow for feeding of virtually any size and shape stock being turned, including but not limited to round, hex, square, and extruded. Furthermore, the inner bore is molded into the spindle liner along its entire length providing absolute support of the workpiece. The spindle liner has a flanged mounting end to allow for proper orientation and attachment to the spindle.

15 This invention also presents a method of forming a unibody liner for a lathe spindle, including providing a mold for forming the unibody liner having an axial core piece that defines the through-opening of the liner. The core is intended to closely match the dimension of the workpiece to be machined. The mold includes an upper cap having a fill hole and a center locator pin that, in
20 conjunction with a central pin disposed at the opposite end of the mold, secures and maintains the core piece in concentric alignment with the central axis of the mold. The poured polyurethane typically sets up within 15-30 minutes, after which time the molded liner is removed from the mold and placed in an oven for approximately 8-10 hours at 150 degrees F to complete the curing process.
25 Thus, once the operator receives an order for a liner of specific dimensions, the liner mold may be configured to match the outer diameter and through-opening specifications, the urethane material poured in its liquid or molten state into the mold, the cured liner may then, after about 15-30 minutes, be removed from the mold, baked in a curing oven for about 8-10 hours, and then shipped to the
30 customer, all within a single working day if necessary.

Such a one-piece, unibody liner provides many advantages over conventional metal spindle liners. The liner of this invention is considerably lighter in weight than metal liners. The reduced weight translates into less rotating mass within the spindle, thus lowering wear on the spindle and the
35 turning machine. Another advantage is that the inner bore of the spindle liner of this invention can be molded to the shape and size of any stock being fed through the spindle. The bore for non-round stock is molded into the entire liner as

5 opposed to just a few locations in the conventional metal liners. This allows for optimal control of bar whip and its associated problems.

 In the conventional liner, a non-round work piece is not held or secured at all points along the entire length of the liner; it is held at only 2 or 3 locations along its length by pins or dowel rings. Consequently, as the non-round
10 workpiece is being indexed, i.e., pushed/pulled, through the spindle during the cutting process, there's a greater chance that the workpiece will rotate out of concentric center, thereby producing whip.

 Furthermore, the spindle liner consists of, preferably, polyurethane material which has significantly higher vibration dampening or reduction
15 properties than the metal material in conventional spindle liners. The liner provides the ability to hold proper part tolerances, thereby reducing scrap rates and increasing productivity. The bar stock is also protected from marring or scratching by the liner. The liner also reduces the wear on machine cutting tools due to the vibration deadening properties of the material from which it is
20 constructed. Noise is also considerably reduced by the use of this novel liner. The machining operation is also able to be operated at a faster turning speed, while maintaining optimal machine control, thereby leading to improved productivity.

 Multiple sizes or slightly bowed bar stock may be run in the same spindle
25 liner because of the mechanical integrity and properties of the polyurethane material. The one-piece polyurethane spindle liner is also more durable and virtually indestructible as compared to the conventional metal spindle liner. It is also non-corrosive. Finally, the one-piece liner cost considerably less (upward to 50% less) to manufacture than the current industry standard metal liner.

30 This invention also provides a method of forming the one-piece polyurethane spindle liner that allows for significantly shorter delivery or lead times than the current industry standard for conventional metal spindle liners. Once the spindle inside diameter(s) is established for a specific machine make, a mold can be created to establish the spindle liner outside diameter. The only
35 variable that remains is the shape and size of the inside diameter of the throughbore of the spindle liner. The mold core determines the cross-section of the spindle liner and can easily be changed as needed. Once the machine tool

5 spindle inner dimension is known and the mold is established, the lead time can be as short as the same day to within a couple of days from the receipt of the order.

To overcome the above problems and shortcomings of the prior art, it is an object of the present indication to provide a bar stock support to minimize
10 whipping and other undesirable radial or lateral motion of the bar stock while in the spindle during machining. Another object is to provide an inexpensive spindle liner that is simple to manufacture, thereby enabling an operator to have one or more of the liners of this invention readily on hand to accommodate workpieces of varying diameter and cross-sectional shapes.

15 Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

Brief Description of Drawings

20 The foregoing and other features of the invention will be more particularly described in connection with the preferred embodiment and with reference to the accompanying drawings wherein:

Fig. 1 is an environmental view in phantom perspective of a conventional turning machine such as a lathe equipped with the spindle liner of this invention;

25 Fig. 2 is a perspective view of a prior art spindle liner;

Fig. 3 is a perspective view of the preferred spindle liner of this invention;

Fig. 4 is a sectional fragmenting side view of a lathe with the spindle liner of Fig. 3 ;

30 Fig. 5 is an end view of an alternative embodiment of the liner provided by the invention;

Fig. 6 is a cross-sectional view of a preferred mold for forming the liner of this invention; and

Fig. 7 is top view of the spindle liner mold of Fig. 6.

5 **Best Mode for Carrying Out the Invention**

Referring now to the drawings wherein like reference numerals designate identical or corresponding parts or elements throughout the several views, Fig. 1 shows in phantom lines a conventional turning machine such as a lathe 10 comprising a head stock 12 including a chuck (not shown) and a spindle 20. Not shown is Fig. 1 but typically present in conjunction with lathe 10 is a track-mounted cutting tool for movement into working engagement with a workpiece W. The workpiece is commonly held by the chuck so that a portion to be worked upon extends beyond the jaws of the chuck and is in a position to be machined by the cutting tool. The spindle liner 30 of the invention is shown positioned within the following spindle of the machine 10.

In Fig. 2, a prior art spindle liner 20 widely used in industry today is shown. Liner 20 has a tubular sleeve 22, bearing rings 23 and an annular mounting flange 24. While the tubular sleeve has a length dependent on the lathe in which it is to be used, about two feet to about five feet in length is typical. The inside diameter 22a of the liner is dependent on the workpiece it is to accommodate. As known in the industry, a set of spindle liners of varying sleeve diameters is generally needed to accommodate the many workpieces of varying sizes and cross sections. Each sleeve's inside diameter is ideally slightly larger than the diameter or maximum cross-dimension of the workpiece so as to slidably receive the workpiece with a minimum of play. While stock workpiece diameters vary widely, a diameter of from above one-fourth inches to about six inches is commonly used, though smaller and larger diameter workpieces are also available. The tubular sleeve 22 of the spindle liner 20 is dimensioned to accommodate virtually any sized workpiece that the lathe is built to handle.

The bearing rings 23 comprise an annular member 25 permanently secured to the outside surface of the tubular sleeve 22 and a resilient O-ring 26 disposed in a groove extending around annular member 25. Their purpose is to bear against the inside wall of the hollow spindle to stabilize the spindle liner and its associated workpiece during the cutting operation. Accordingly, the outside diameter of the bearing rings is dimensioned to allow the spindle liner to slide into the hollow spindle of the lathe with a minimum of play. Inasmuch as each lathe is dimensioned differently, each bearing ring on the spindle liner is

5 specially dimensioned for that particular lathe. The bearing rings are substantially uniformly spaced along the tubular sleeve 22 of the liner in accord with requirements well known to those in the industry. Liner 20 is releasably secured to the spindle of the turning machine by way of a plurality of bolt holes 29. Such a conventional liner is burdened with the aforementioned
10 disadvantages.

The spindle liner 30 of this invention is better shown in Figs. 3 and 4 comprising an elongated, one-piece tubular sleeve member 31 having an axial central opening 32 extending entirely the length of the liner 30, and amounting
15 flange 34 for securing the liner at the spindle terminus opposite the stock end of the turning machine 10 where the chuck 13 is located. Flange 34 is circular-shaped and includes one or more bolt holes 36 (not shown in Fig. 4) to secure the liner near the back 14 of the turning machine.

As shown more clearly in Fig. 4, the spindle liner 30 of this invention substantially fills the void between the outer surface W' of the workpiece W
20 (shown in phantom in Fig. 4) and the interior surface of the spindle 16. The spindle 16 fits within a draw tube 18 that is part of a conventional cutting machine. In a preferred embodiment, the longitudinal dimension "L" to fit most CNC cutting machines in use today is typically 24 inches to 60 inches; however, the length of the liner is not limited.

— 25 As noted, the liner of this invention may be readily formed to accommodate workpieces of varying cross sections. An end view of such an alternative embodiment of a spindle liner 130 of this invention is shown in Fig. 5 having a mounting flange 134 with one or more through holes 136 for securing the liner 130 to the spindle. The central axial opening 132 of spindle liner 130 is
30 configured to accommodate square bar or tube stock and maintain the stock's orientation to the chuck. The outer dimension of the flange 134 can be from about 3 inches to about 6 inches, but can be any size as desired. In one example, the outer dimension of flange 134 is approximately 4.25 inches, and the outer cross-dimension of the tube sleeve portion 131 is approximately 2.56 inches. In
35 use, the dimension of opening 32 or 132 can be a variety of sizes and cross sections as determined by the specifications of the workpiece being turned by the
— customer.

5 A preferred mold for forming a spindle liner of this invention is shown in Figs. 6 and 7, comprising a hollow mold 50 including an elongated tubular portion 52 having a mounting-flange forming portion 54 at one end and an end cap 56 at the opposing end. Mold 50 may be constructed of conventional mold-forming materials (i.e., stainless steel) via conventional methods.

10 Extending and secured concentrically within the interior length of the mold is a core element 58 that defines the dimension of the axial through-opening of the spindle liner. For example, to form the spindle liner shown in Fig. 5, the core element 58 would have a generally square cross-section of approximately 1 in. square. Core element 58 is maintained in proper concentric orientation within

15 the mold by a pair of threaded pins 58a and 58b disposed at the opposite ends of core 58. Again, the through-opening of the liner of this invention can be easily varied by simply changing the core element to one matching the desired specifications to accommodate the subject workpiece.

 The interior surface 52a of the tubular section 52 of the mold defines the

20 outer circumferential surface of the liner once formed, which is slightly less than the interior diameter of the spindle for which the liner is being made in order for the liner to be received within the spindle with minimal play. The annular cross-section of the tubular portion 31 of the spindle liner is formed within the void area 52b of mold 50. The mounting flange 34 of the spindle liner of this

25 invention is formed within the void area 54b of the mold.

 The method provided by this invention includes the steps of determining the outer dimension of the subject workpiece, whether it be hex, square or round bar or extended stock; determining the inner diameter of the spindle of the turning machine upon which the subject workpiece will be machined; selecting

30 an appropriate core element approximately the dimensions of the subject workpiece; selecting an appropriate tubular mold section having an inner diameter slightly less than the inner diameter of the spindle, which in turn will approximate the outer diameter of the liner once formed; selecting an appropriate flange-forming mold portion providing a mounting flange of the appropriate

35 dimensions to be mounted upon the back end of the turning machine; selecting an appropriate top or end cap to fit the selected tubular mold portion; assembling the flange-forming mold portion to the tubular mold position; securing the

5 central core element interiorly of the tubular mold portion by placing the top cap atop the open end of the tubular mold portion and securing the upper end of the core element by way of a fixing pin; introducing liquid polyurethane in a molten state into the interior of the mold so formed through a fill hole provided in the top cap until the interior void of the mold is substantially filled; and allowing the
10 molded liner to set up for an appropriate length of time to permit the polyurethane to cure to a sufficient state.

The preferred material for constructing the spindle liner of this invention is polyurethane. It should be understood, however, that any plastic material that may be poured into a mold and that cures and hardens in a relatively short time
15 may be suitable.

Although the present invention has been described with a preferred embodiment, it is to be understood that variations and modifications may be made without departing from the scope of this invention as set forth in the following claims. Such variations and modifications are considered to be within
20 the purview and scope of the appended claims.